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(54) **Drilling fluid**

(57) A water based drilling fluid comprises:
(a) an aqueous medium,
(b) a cationic polysaccharide in amount 2-15 pounds per barrel (5.72–42.9 g/litre),
(c) a water soluble polyacrylamide in amount 0.25–3 pounds per barrel (0.72–8.58 g/litre), and
(d) a water soluble salt of an alkali or alkaline earth metal in amount 5–50 pounds per barrel (14.3–143 g/litre).

The combination of the cationic polysaccharide and the polyacrylamide is particularly effective in providing both fluid loss control and enhanced shale inhibition.

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DRILLING FLUID

This invention relates to a water-based drilling fluid which is suitable for use in shale formations.

A drilling fluid is used in conjunction with the rotary system of drilling. The drilling fluid is pumped from the surface down the inside of the rotating drill string, discharged through ports in the bit and returned to the surface via the annular space between the drill string and the hole.

The drilling fluid serves to cool and lubricate the bit and drill string, bring drill cuttings to the surface, consolidate the side of the drilled hole, prevent squeezing-in or caving of the formation, control subsurface pressures, suspend drill cuttings when the column is static and minimise damage to any potential pay zone that might be encountered.

Drilling fluids generally contain a carrier, a weighting agent and chemical additives. They are commonly divided into two categories, water based muds (WBM) and oil based muds (OBM). In the former the carrier is an aqueous medium and in the latter it is an oil. Diesel oil was used in the past as the oil, but recently low toxicity drilling oils have been developed for this purpose.

While WBM are more environmentally acceptable than OBM (since the latter still give rise to the problem of disposing of large quantities of oil contaminated drill cuttings, even if the oil is of low toxicity), they are recognised as being technically inferior in a number of important areas, such as thermal stability, lubricity, shale inhibition.

Although shale is soft and therefore relatively easy to drill through, it still causes many problems for the drilling engineer. It disperses easily into the fluid, large lumps break off and fall into the hole, pores in the shale can contain fluids trapped under pressure, and in extreme cases, the borehole wall may collapse.

Since shale makes up a high proportion of the rocks drilled in exploratory and production wells for oil and gas, particularly in important producing areas such as the North Sea, it is important that drilling times and problems be kept to a minimum when drilling through such formations.

Many WBM formulations incorporating additives have been suggested in an attempt to control reactive shales. Such additives include:

(a) salts such as potassium chloride to limit water uptake, reduce the swelling of the shale, and reduce leaching of any salt deposits encountered,

(b) sodium carboxymethyl cellulose (CMC) or starch which is used to reduce fluid loss,

(c) water soluble polyacrylamides which adsorb on the surface of shale to bind it with a coating of polymer, thereby reducing dispersion of the shale,

(d) lime or gypsum which, although sparingly soluble, act in a similar manner to (a), and

(e) gilsonite which assists in fluid loss control by acting as a blocking agent for cracks and microfractures.

To date, however, none of these formulations has been able to provide shale inhibition to the levels achieved with OBM.

This is because an OBM does not react with shale. A conventional WBM will, however, react to a greater or lesser extent with many shales causing them to swell and can give rise to problems such as stuck pipe, tight hole, overgauge hole, poor directional control, poor cementing and poor mud condition (leading to extensive dumping and diluting and therefore high mud costs).

It is an object of the present invention to develop a WBM which approaches the technical performance of an OBM without sacrificing

its environmental advantages.

We have now discovered that the combination of a cationic polysaccharide and a polyacrylamide is particularly effective in providing both fluid loss control and enhanced shale inhibition.

Thus according to the present invention there is provided a water based drilling fluid comprising:

(a) an aqueous medium,

(b) a cationic polysaccharide in amount 2 - 15 pounds per barrel (5.72 - 42.9 g/litre), preferably 4 - 8 pounds per barrel (11.44 - 22.88 g/litre),

(c) a water soluble polyacrylamide in amount 0.25 - 3 pounds per barrel (0.72 - 8.58 g/litre), preferably 0.5 - 1.5 pounds per barrel (1.43 - 4.29 g/litre), and

(d) a water soluble salt of an alkali or alkaline earth metal in amount 5 - 50 pounds per barrel (14.3 - 143 g/litre), preferably 10-40 pounds per barrel (28.6 - 114.4 g/litre).

The fluid may also contain additional conventional ingredients such as water-insoluble weighting agents, eg, barite, haematite or galena; viscosifiers, eg xanthan gum, and pH control agents, eg sodium or potassium hydroxide. The pH is suitably controlled to a value in the range 7 to 13.

The aqueous medium may be fresh or saline water.

The cationic polysaccharide is preferably a cationic starch.

The cationic starch may be a tertiary aminoalkyl ether of starch which is manufactured by reacting an alkaline starch slurry with 2-dimethylaminoethyl chloride. Another suitable cationic starch is a quaternary ammonium ether of starch formed by reacting an alkaline starch slurry with N-(2,3-epoxypropyl)-trimethyl ammonium chloride.

Suitable cationic starches include those sold under the Trade Name Catogel by National Starch and Adhesives.

The polyacrylamide may be a cationic polyacrylamide. Suitable cationic polyacrylamides include those sold under the Trade Names Alcomer 230 and 630 by Allied Colloids and Floc Aid 303, 304 and 307 by National Starch and Adhesives.

However it is prefered that the polyacrylamide is an anionic polyacrylamide.

It is a further and unexpected feature of our invention that the combination of a cationic polysaccharide and an anionic polyacrylamide appears to show a synergistic effect and not, as one might expect, an interaction in a harmful manner.

Anionic polyacrylamides contain a proportion of acrylate or acrylic acid groups. These can be made by polymerising acrylamide and hydrolysing some of the amide groups which can then be converted to a salt. Alternatively they can be made by copolymerising acrylamide and an acrylate or acrylic acid and converting to a salt.

Suitable anionic polyacrylamides are those sold under the Trade Names Alcomer 120L by Allied Colloids, Floc Aid 201, 203 and 204 by National Starch and Adhesives and Drillam EL by Lamberti.

Suitable water-soluble salts of alkali or alkaline earth metals include the chlorides of sodium, potassium, calcium and magnesium. The preferred salt is potassium chloride.

The invention is illustrated with reference to the following Examples.

Examples

The following procedure was used for Examples 1-3. Muds were prepared by dissolving the polymers in fresh (distilled) water and allowing the mixture to age for a minimum of 30 minutes. All mixing was carried out on a Hamilton Beach mixer. KCl, barite and synthetic drilled solids were added at the required levels to the solution of polymers and, finally, the pH was adjusted with potassium hydroxide. The drilled solids were added to simulate contaminants which would be present when drilling in a field.

Rheological measurements were made using a Fann Model 35SA viscometer.

Cuttings dispersion tests were carried out by placing a known weight (approximately 20 grams) of 2-4 mm shale chips in a steel ageing bomb with 350 ml of mud. The bomb was sealed and rolled for 16 hours at 130°F (54°C) after which any undispersed shale was collected on a 500 micron sieve, washed, dried and weighed. The

percentage of the starting weight of shale recovered was then calculated.

Dispersion tests were carried out on two types of shale: Oxford Clay and Kimmeridge Clay. Both are Upper Jurassic in age.

Example 1

Example 1 is a comparative example showing the formulation and properties of a conventional WBM. It is not in accordance with the present invention.

Example 2 is a preferred embodiment containing cationic starch and anionic polyacrylamide.

Example 3 is a less preferred embodiment containing cationic starch and cationic polyacrylamide.

The compositions of the formulations of Examples 1, 2 and 3 are set out in the following Table 1.

Table 1

Component	Example 1	Example 2	Example 3
Fresh Water	As Basestock	As Basestock	As Basestock
KCl	25	25	25
Xanthan gum (1)	2	2	2
CMC (2)	4	-	-
Cationic starch (3)	-	4	4
Anionic polyacryamide (4)	1	1	-
Cationic polyacrylamide (5)	-	-	1
Drill solids	30	30	30
Barite	to SG 1.3	to SG 1.3	to SG 1.3
KOH	to pH 9.0	to pH 9.0	to pH 9.0

All concentrations are in ppb (pounds per barrel) unless otherwise stated. 1 ppb = 2.86g/l

(1) Xanthan gum - XC Polymer, ex Kelco

(2) CMC-Na Carboxymethyl cellulose - CMC Lovis, Ex Baroid

(3) Cationic starch - Catogel, ex National Starch and Adhesives

(4) Anionic polyacrylamide - Alcomer 120L, ex Allied Colloids

(5) Cationic polyacrylamide - Alcomer 630, ex Allied Colloids

Table 2

Property	Example 1	Example 2	Example 3
Rheology			
Apparent Viscosity (AV) cP at 25°C	60	40	35
Plastic Viscosity (PV) cP at 25°C	30	21	15
Yield Point (YP) lb/100 ft^2 (6)	65	43	40
API Fluid Loss (corrected) ml	4	5.4	7.5
Shale Inhibition			
Recovery from Cuttings Dispersion Test			
Oxford Clay %	94.5 (7)	99.8	99.3
Kimmeridge Clay %	90.3 (8)	99.4	99.0

(6) 1lb/100 ft^2 = 0.5 Pa

(7) The cuttings were swollen and dispersive after testing

(8) The cuttings were unswollen and dispersive after testing

Examples 2 and 3, which are in accordance with the present invention, show improved recoveries over Example 1, which is not.

Example 2 shows a somewhat better recovery than Example 3.

In addition, the cuttings recovered in Example 3 were softer than in Example 2 and would be more prone to disperse in a drilling fluid under downhole conditions.

Claims

1. A water based drilling fluid comprising;

(a) an aqueous medium,

(b) a cationic polysaccharide in amount 2-15 pounds per barrel (5.72-42.9 g/litre),

(c) a water soluble polyacrylamide in amount 0.25-3 pounds per barrel (0.72-8.58 g/litre), and

(d) a water soluble salt of an alkali or alkaline earth metal in amount 5-50 pounds per barrel (14.3-143 g/litre).

2. A water based drilling fluid according to claim 1 comprising:

(a) an aqueous medium,

(b) a cationic polysaccharide in amount 4-8 pounds per barrel (11.4-22.88 g/litre),

(c) a water soluble polyacrylamide in amount 0.5-1.5 pounds per barrel (1.43-4.29 g/litre), and

(d) a water soluble salt of an alkali or alkaline earth metal in amount 10-40 pounds per barrel (28.6-114.4 g/litre).

3. A water based drilling fluid according to either of the preceeding claims containing in addition one or more components selected from the group consisting of weighting agents, viscosifiers and pH control agents.

4. A water based drilling fluid according to claim 3 wherein the weighting agent is barite.

5. A water based drilling fluid according to claim 3 or 4 wherein the viscosifier is xanthan gum.

6. A water based drilling fluid according to any of claims 3 to 5

wherein the pH is controlled to a value in the range 7-13.

7. A water based drilling fluid according to any of the preceding claims wherein the cationic polysaccharide is a cationic starch.

8. A water based drilling fluid according to claim 7 wherein the cationic starch is a tertiary aminoalkyl ether of starch or a quaternary ammonium ether of starch.

9. A water based drilling fluid according to any of the preceding claims wherein the polyacrylamide is a cationic polyacrylamide.

10. A water based drilling fluid according to any of claims 1 to 8 wherein the polyacrylamide is an anionic polyacrylamide.

11. A water based drilling fluid according to any of the preceding claims wherein the water soluble salt of the alkali or alkaline earth metal is a chloride.

12. A water based drilling fluid according to claim 11 wherein the chloride is potassium chloride.

13. A water based drilling fluid according to claim 1 as hereinbefore described with reference to the Examples.

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